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HYPERSPECTRAL AND EXTREME LIGHT DIAGNOSTICS FOR DEFENSE-CRITICAL ADVANCED MATERIALS PROCESSES

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Final Report

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The objective of this MURI program is to develop the scientific basis for use of ultrafast lasers as materials diagnostics and microfabrication tools for advanced materials and components in Air Force systems. The program is composed of collaborative projects that aim to (1) understand the fundamentals of laser – material interaction for metallic, intermetallic and ceramic materials; (2) quantify the capabilities and/or extend the limits of individual laser-based material interrogation modes, including xray diagnostics, terahertz tomography and “non-destructive” laser-induced breakdown spectroscopy (LIBS) (3) investigate the capability of each technique to detect a particular form of damage; (4) integrate the diagnostic techniques to track damage evolution and provide input to models for component life. This MURI supports the critical Air Force need for new state awareness and prognosis technologies.

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FA9550-05-1-0416: **Hyperspectral and Extreme Light Diagnostics for Defense-Critical Advanced Materials and Processes (U. Michigan)**

The objective of this MURI program is to develop the scientific basis for use of ultrafast lasers as materials diagnostics and microfabrication tools for advanced materials and components in Air Force systems. The program is composed of collaborative projects that aim to (1) understand the fundamentals of laser – material interaction for metallic, intermetallic and ceramic materials; (2) quantify the capabilities and/or extend the limits of individual laser-based material interrogation modes, including x-ray diagnostics, terahertz tomography and “non-destructive” laser-induced breakdown spectroscopy (LIBS) (3) investigate the capability of each technique to detect a particular form of damage; (4) integrate the diagnostic techniques to track damage evolution and provide input to models for component life. This MURI supports the critical Air Force need for new state awareness and prognosis technologies for complex “life-critical” components in aircraft, engines and spacecraft.

There has been substantial progress in demonstrating the feasibility and potential utility of the laser-based diagnostics for the characterization of the structure and defects in advanced materials of relevance to aircraft engines. New insights to the mechanisms of ablation and the formation of collateral damage have been established. These insights have permitted new modes of microfabrication, tomography and microanalysis. Future progress in the application of these laser-based sources in a rapid multi-spectral mode is enabled by new developments with chirped volume Bragg gratings that enable high average power fiber lasers. In the remaining portion of the program we will continue to quantify the fundamental limits of the laser-based diagnostics, particularly in the area of x-rays. We will also demonstrate the feasibility of multimodal analysis within a single laser platform. Our experimental accomplishments to date will now enable a greater emphasis on modeling, with a major objective being to connect molecular dynamics, dislocation dynamics and hydrodynamics simulations to more fully quantify the response of the materials of interest to ultrashort pulses. Fatigue and fracture mechanics modeling will also be utilized to connect the new insights gained in cyclic experiments to existing life prediction methodologies.